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Application of Passive Design Strategies for Fire Protection in Office Buildings, Minna, Niger State

Salako A.[*], *Chukwudum J. Eze*

Department of Architechture, School of Environmental Technology, Federal University of Technology, Minna, Nigeria
a.salako@futminna.edu.ng

Abstract

Nigeria continues to have a serious problem with fire occurrences in office buildings, which result in property damage and fatalities. Passive fire safety techniques are commonly disregarded, even in the face of current fire regulations, even though they are essential for limiting the spread of fire. In this study, office buildings in Minna, Niger State, Nigeria, are studied to see how effective passive fire prevention is. Architects, builders, and managers' understanding of passive fire safety will be evaluated, along with the effectiveness of various solutions being identified and gaps in design being highlighted. Case studies, questionnaires, and on-site observations were used to collect data using a descriptive methodology. The results indicate that a considerable proportion of office buildings in Minna are deficient in adequate passive fire safety measures, often depending largely on active systems. The evaluation revealed that only 65% of the buildings adhered to acceptable fire safety standards, underscoring a significant need for enhancement. Additionally, the study highlighted effective passive design strategies, including the use of fire-resistant materials and appropriate compartmentalization, which can markedly improve fire safety results. In conclusion, the thesis advocates for architects, builders, and regulatory bodies to emphasize the incorporation of passive fire protection strategies in architectural designs. It is also imperative to enhance training and education regarding fire safety protocols for industry professionals to ensure the successful implementation of these strategies. By following these recommendations, stakeholders can elevate fire safety standards, ultimately safeguarding lives and property in urban settings.

Keywords: architectural design, fire protection. fire outbreak, office buildings, passive fire safety,

1. Introduction

1.1 Background of the Study

Office buildings is structures that plays a crucial role in urban economic growth (Surya, 2020). The building can be built with no confirmed tenants if it is assumed that tenants will eventually lease the space. Alternatively, it could be made to satisfy the unique demands of the corporate offices. (Yates, 2021). The design and construction of a building that offers a cozy and healthful atmosphere for users is referred to as building performance (Bakens *et al*., 2005; Ibem *et al*., 2013). Therefore, one way to assess the effectiveness of the building system is to look at maintenance demand data that represents how users perceive the efficacy of the services the building offers.

The National Building Codes, created by the Federal Government of Nigeria, provide minimum requirements for structures at every stage of the building process, from pre-design to post-construction. These codes ensure safety and professionalism in the building industry, addressing issues like collapses, fires, and environmental abuses. However, despite regulatory frameworks, challenges such as code complexity, access difficulties, weak enforcement, and affordability demands persist (Owino, 2022). This highlights the urgent need for effective fire safety measures in building design and construction, especially in office buildings. Professionals often face constraints due to the complexity of the codes, difficulties in accessing them, weak enforcement of the law, and client demands regarding affordability. Similar challenges are observed in developed countries, where regulatory failures in building fire protection are evident (Oscar *et al.,* 2021). Passive fire protection systems are built-in safety measures designed to prevent the spread of fire through the use of fire-resistant walls, floors, and doors. Unlike active systems that require manual or automatic activation (such as sprinklers), passive systems work by containing the fire within designated compartments, limiting its spread. An effective fire protection system is essential for safeguarding buildings against fire hazards and minimizing potential losses, especially in public facilities These systems focus on the building's design, architecture, and structure, helping to inhibit fire propagation and facilitate evacuation. They are considered one of the most cost-effective fire protection solutions, as they not only save lives but also reduce damage to property (Kater, 2011).

There is an urgent need for research on passive fire protection techniques because office buildings in Nigeria are seeing an increasing number of fire occurrences (Babatunde *et al.,* 2020). These strategies have the ability to significantly reduce the chance of a fire spreading and improve occupant safety when they are effectively integrated into building design (Cvetković *et al.,* 2022). The results of this study will provide architects, builders, and legislators with essential data that will help them create office buildings that not only adhere to fire safety regulations but also have affordable and environmentally friendly fire protection systems.

2. Literature review

2.1 Meaning and Types of Office Buildings

An office building is a type of building used by businesses, government agencies, and nonprofits for professional and administrative purposes. For work-related activities including meetings, research, communication, and teamwork, it offers a formal setting. Conference spaces, individual offices, lobby areas, open-plan layouts, and service spaces like cafeterias, lavatories, and storage rooms are frequently found in office buildings (Rasheed *et al*., 2024). Office building have continuously increased in numbers in all part of the globe under the support of technological development and scientific innovation that have seen to its incorporation of requisite human life support systems (Leadership News, 2017). Offices now serve as collaboration spaces, talent recruitment, onboarding, and inspiration, with integrated design offering increased worker satisfaction, productivity, health improvement, flexibility, and enhanced energy and environmental performance (Danto, 2024). The building features emergency drills, natural light, backup power generators, fresh air, thermal comfort, sound, materials, and community support, enhancing occupant comfort and promoting well-being, safety, and satisfaction. (Dutcher, 2007).

2.2 Classes of Office Buildings

Classification plays a critical role in the design and development of office buildings since it affects the functional needs and architectural style. Classification is influenced by elements including location, building height, architectural style, tenant needs, and space purpose (Salam,2022). Office buildings are divided into three primary classes, Class A, Class B, and Class C. This classification system offers a foundation for comprehending elements of design, quality, and market placement.

1. Class A office building

These are the most prestigious buildings competing for premier office users with rents above average for the area and have a definite market presence. Class A buildings have a prime central location with exceptional accessibility and are usually of significant size (Blum, 2022). Class A boasts high-end tenant improvements and high-quality, first-class finishes, high-tech security, the latest in elevator and HVAC systems, and state-of-the-art technological capabilities (Catalano, 2024). Tenants who seek out Class A properties are usually businesses for whom office space is not just for employees, but also for clients and they want to give a top-notch impression. These businesses are often found in financial districts and may provide professional services like law firms, architecture firms, advertising agencies, or financial management companies (Tross, 2024).

2. Class B office building

Class B building are usually older buildings that have generally been maintained over the years. They are often located in areas that used to be prime areas of the city as well as some parts of the current choice areas, they tend to command average rental rates. Most of these buildings are fewer than four stories tall and located in suburbs or the periphery of large financial districts (Blum, 2022). Class B buildings retain an acceptable curtain wall finish, adequate mechanical, electrical, safety, security systems, and mid-quality interior finishes (Mohammed & Kaseem, 2022). The distinguishing factor between a class A vs class B building is the quality and variety of amenities and building finishes. These office spaces compete for a wide range of users that want average rental rates for their market areas (Tross, 2024).

3. Class C office building

Class C buildings are generally office spaces built over 20 years ago with outdated designs, aesthetics, and general quality, often located in the least favourable parts of the city. They are often sought after by start-up businesses, are relatively few, require extensive renovations or reconstruction, have the lowest rental rates, take the longest time to lease, and are often targeted as re-development opportunities (Maria *et al*, 2013). Class C property tenants may include small service-orientated or industrial businesses such as companies that do engineering, landscaping, sign making, security, construction, plumbing, and electrical. Its minimal amenities include onsite parking and break rooms (Blum, 2022).

In developing countries, Fires are a significant cause of deaths and disabilities in Nigeria, causing significant loss of life and property. The lack of information about fire safety is a major reason for frequent fires in residential structures, emphasizing the need for urgent action to address fire incidence. (Lawal *et al*., 2018). Nigeria's majority of homes lack fire protection devices, and as office buildings expand, concerns about fire safety in these structures are growing due to multiple fire incidents (Yatim *et al*., 2006).

2.4 Fire Protection system

Nigeria NFPA defines fire protection as all measures taken to reduce the burden of fire on the quality of life. In simple terms, fire protection is about implementing measures and strategies that will stop the spread and intensity of a fire, while also reducing its potential impact and damage. Fire protection systems are essential components of building safety, offering various methods to detect, suppress, education, training, planning, and processes to protect everyone and everything from fires. Fire protection is important because it helps ensure the safety of people and structures. It can decrease fire spread and damage, reduce the likelihood of injuries, and provide safe evacuation routes.

Figure 2. Fire Protection equipment
Source: Basim (2022)

2.5 Passive Fire Protection Passive

Passive Fire Protection (PFP) is a group of systems that compartmentalize a building through the use of fire-resistance-rated walls/floors, doors and gap-filling measures (Raciti, 2021). Passive Fire protection helps to limit the amount of damage done to a building and provides its occupants more time for evacuation. PFP includes fire/smoke dampers, fire doors, and firewalls/floors. Dampers are used to prevent the spread of fire/smoke throughout the building through its ductwork (Hsiao *et al*.,2023). Fire doors help to compartmentalize a building. Fire stopping helps to separate the building into compartments. Photoluminescent egress path markers help light the way to safety. The purpose of the escape stairs is to facilitate the prompt evacuation of building occupants in the event of a fire (Nachtigall, 2017). Examples of passive fire protection:

1. Fire doors 2. Fire walls 3. Fire floors 4. Emergency exit lights 5. Dampers 6. Flame shields 7. Intumescent paint 8. Mortar coating 9. Mineral Fiber matting 10. Protection of muster/refuge points
11. Spray fireproofing

2.5.1 Passive Fire Strategies in Office Buildings

Five essential passive fire protection strategies used throughout the industry are:

1. **Fire-Resistant Materials:** Materials such as resistant walls, floors, and doors constructed from materials like gypsum, concrete, fire-retardant-treated wood, and special coatings. These materials can resist fire for a specified duration, allowing occupants more time to evacuate and fireFigurehters more time to contain fires.
2. **Compartmentalisation and Fire Barriers:** Dividing buildings into compartments, or fire zones, separated by fire-resistant walls and floors can stop the rapid spread of fire and smoke, confining it to limited areas, and preventing it from engulfing the entire structure.
3. **Fire Dampers and Smoke Barriers**: Install fire dampers within heating, ventilation, and air conditioning (HVAC) systems to prevent the spread of fire and smoke through ductwork. Smoke barriers are fire-rated walls designed to impede smoke movement, aiding in the containment of fire and ensuring safer escape routes for occupants.

4. **Structural Fire Protection:** Using fire-resistant coatings, fireproofing sprays, or intumescent paint on structural components like columns, beams, and load-bearing walls helps to delay the weakening of a building's structure during a fire.
5. **Penetration Seals and Firestopping:** Seal openings and penetrations in fire-rated walls and floors, such as cable trays, pipes, ducts, and electrical outlets, using fire-resistant materials. Firestopping techniques prevent the spread of fire and smoke through these openings, maintaining the integrity of fire-rated barriers.

3. Methodology

A research method is a means of data collection or data generation. Conventionally, research methods are categorized as quantitative methods such as surveys, questionnaires, qualitative methods such as interviews and focus groups or combination of the two in mixed methods research (Bhardwaj, 2019). The type of this research is descriptive research. This design enables the collection of detailed information from a sample of professionals involved in the design, construction, and management of office buildings in Minna. Within the selected office buildings, 320 experts working in the fields of architecture, construction, and facility management received questionnaires. Of these, 224 correctly completed and returned surveys resulted in a 70% response rate. A total of 96 surveys were not returned or were incomplete, indicating a 30% non-response rate. Purposeful sampling was used to calculate the sample size, with a focus on experts in the research area's building design, construction, and maintenance.

On-site observations were another part of the data gathering procedure, when passive fire protection devices such fire-resistant doors, walls, and emergency exits were examined to evaluate how well they integrated and worked. In addition to the main data, a thorough assessment of the literature was done with an emphasis on passive fire prevention techniques and current fire safety laws. Descriptive statistics were used to evaluate the questionnaire data, and frequency distributions, pie charts, and bar charts were used to display the findings. Data analysis was conducted using the Statistical Package for Social Sciences (SPSS) software, which yielded insights on the incidence and effectiveness of passive fire methods in the buildings.

4. Discussion of Results

This chapter serves as a comprehensive overview of the research findings derived from the survey conducted among office building occupants in Minna. It is structured to align with the specific objectives set forth at the beginning of the study, ensuring that the results are relevant and directly address the research questions.

Demographic Information

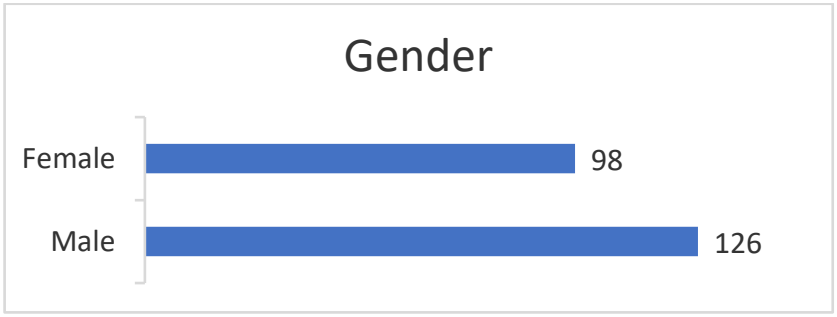

Figure 1: Gender distribution of participants.

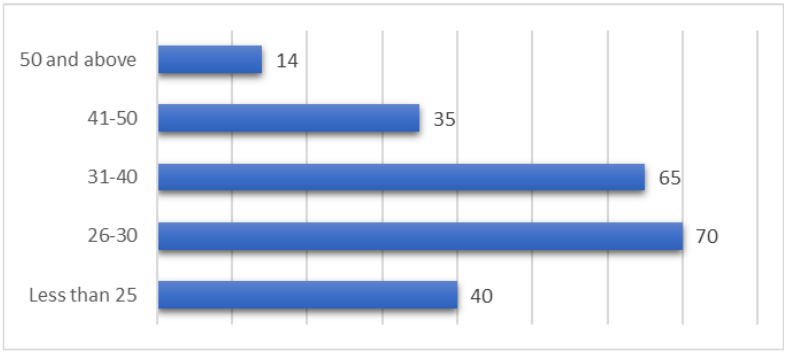

Figure 2: Age distribution of participant.

Assessment of Fire Safety Systems in Selected Office Buildings

This section presents the analysis and findings of the buildings that were inspected; Table 1 displays the fire safety system used in the study. X denotes an acceptable fire system, Y an insufficient fire system, and Z no fire system.

Table 2: Existing Fire Safety Measures in in Selected Office Buildings

Name of Office buildings	Place of safety	Escape Stairs	Fire door	Travel distance	Emergency lighting	Fire alarm	Exit signage	Fire access	Artificial lighting	Fire Extinguisher
Senate Building Futminna	X	X	Y	Y	X	X	X	Y	Y	X
NSDC Building Minna	Y	X	X	Z	X	X	Z	X	Y	X
Department Of Petroleum Resources Corporate office	X	X	X	X	X	X	X	X	X	X
Niger State Water Board	X	X	Y	Y	X	X	X	Y	Z	X
NICON Insurance Corporation	X	X	X	Y	X	X	Y	Y	X	X

The analysis of fire safety systems in five office buildings categorized them as Acceptable (X), Insufficient (Y), or None (Z). Overall, 50% of the systems were rated acceptable, 30% insufficient, and 20% had no systems. Building-specific insights indicated that the Senate Building had mixed results and required upgrades in emergency lighting and fire extinguishers. The NSDC Building showed critical deficiencies, necessitating immediate action for emergency lighting installation. In contrast, the Department of Petroleum Resources performed excellently, with all systems rated as acceptable, serving as a model for others. The Niger State Water Board needed improvements in fire doors and emergency lighting, while the NICON Insurance Corporation had mixed results, highlighting the need to enhance fire door and alarm systems. A common trend across multiple buildings was the deficiency in emergency lighting and fire doors, indicating a systemic issue in fire safety preparedness.

Training and Awareness of Fire Safety Protocols Among Office Building Occupants

Training and awareness of fire safety protocols revealed that 10.71% of respondents receive no training at all, 22.32% occasionally, and 66.96% of respondents receive regular training. Not all respondents have regular training or understanding of fire safety; 22.32% of occupants are occasional, and 10.71% have never had any training as illustrated in Table 3 below. Passive design elements should be covered in training to provide efficient emergency response, and regular drills and training sessions should be required for complete guidance.

Table 2: Training and Awareness of Participants

Training and Awareness	Frequency	Percentage (%)
Yes, regularly	150	66.96
Yes, occasionally	50	22.32
No	24	10.71

5. Conclusions

This study examines passive design strategies for fire protection in Minna's office buildings, highlighting the current fire safety measures and areas needing improvement. The research addressed existing fire safety systems, effective passive strategies, local practices, and professionals' knowledge. The assessment of five office buildings revealed that only 65% met acceptable fire safety standards, with 24% deemed insufficient and 11% lacking fire safety measures entirely. This highlights a significant complying gap and calls for immediate action to improve fire safety. Implementing fire-resistant flooring, doors, and walls emerged as effective passive fire safety techniques essential for containing fires and ensuring safe evacuation. Such strategies are crucial for minimizing fire spread, thereby allowing occupants vital time to escape and reducing potential casualties and property loss. The findings suggest that future architectural designs in Minna should prioritize passive fire protection measures, including the use of fire-resistant materials and adherence to fire safety codes during design and construction. Such proactive strategies will significantly enhance overall fire safety in these buildings. The study also evaluated architects', builders', and managers' awareness of passive fire safety techniques, revealing that while 66.96% of occupants received regular fire safety training, 10.71% had none. This knowledge gap threatens the effectiveness of passive fire protection systems, highlighting the urgent need for enhanced training and education in fire safety protocols.

6. Recommendation

This study recommends architects, builders, and regulatory authorities in Minna to prioritize passive fire protection strategies in office building design and construction. This encompasses the application of materials that withstand flames, the development of reliable fire safety frameworks, and steadfast compliance with fire protection codes. Moreover, it is vital to enhance training and education regarding fire safety protocols for professionals to ensure the effective implementation of these strategies. By adopting these proactive measures, fire safety outcomes can be significantly improved, thereby protecting lives and safeguarding property in urban environments.

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